

WAFER CLEANING APPARATUS

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BACKGROUND OF THE INVENTION

5 Field of the Invention:

[0001] The present invention relates to a wafer cleaning apparatus for cleaning wafers, which are processed by various processing steps such as plating and chemical mechanical polishing.

Description of the Related Art:

10 [0002] When metallic materials such as copper attach themselves to the surfaces and edges of semiconductor wafers electro-chemically as metallic copper, they become stable and cannot be removed by washing with pure water. Copper adhering in such a manner will diffuse into silicon wafers during heat treatment, and causes problems in device performances.

15 [0003] On the other hand, a copper seed layer is currently formed as a pre-treatment for copper plating by sputtering copper (or by CVD) on the silicon wafer, and the trend is to apply the layer over the entire front surface of the wafer, because it is a more efficient use of the area. That is, as shown in FIG. 1, a barrier layer 80 is formed on the front surface of the wafer W extending to its edge section E, a Cu seed layer 83 is formed thereon, and a
20 plating layer 85 is formed on the seed layer 83.

[0004] However, when a Cu seed layer 83 of 100 nm, for example, is formed by sputtering on the entire front surface of the wafer W, a sputtered Cu layer is formed not only on the front surface of the wafer but a thin sputtered Cu layer is formed also on the edge section E of the wafer as shown in FIG. 2. On the other hand, the formation of the plating
25 layer 85 on the wafer W is carried out by sealing the outer peripheral section of the wafer W so as to prevent the plating layer from extending to the back surface of the wafer W. Therefore, the plating layer 85 can be formed only on the front surface of the wafer W not

extending to the edge thereof, as shown in FIG. 2. For this reason, a portion of the Cu seed layer 83 remains on the edge section E and in the vicinity thereof as a thin layer. The residual Cu layer in such places can detach and be removed from the wafer during transport or processing of plated wafers or chemically mechanically polished (CMP) wafers, thereby leading to a high probability of causing Cu cross-contamination.

[0005] Also, it is difficult to prevent Cu from adhering to the back surface and edge of the wafer even if the edge and the back surface are protected by sealing the outer periphery thereof.

SUMMARY OF THE INVENTION

[0006] The present invention has been derived in view of the background problems outlined above, and an object of the present invention is to resolve such current problems and provide a wafer cleaning apparatus for completely cleaning surfaces of wafers processed by copper plating, a CMP process or so on.

[0007] The present invention provides an apparatus for cleaning front and back surfaces of a wafer while rotating the wafer that has been subjected to a fabrication process. The apparatus comprises: cleaning nozzles for spraying a cleaning solution, respectively, onto a front surface of the wafer that has been processed and onto a back surface thereof; and an etching nozzle for spraying an etching solution onto a vicinity of an outer periphery of the wafer.

[0008] According to cleaning the processed front surface of the wafer, particulate matter and detached copper are eliminated therefrom. According to cleaning the back surface of the wafer, particulate matter and/or copper adsorbed as metallic copper, are eliminated. And according to etching the edge portion of the wafer, it is possible to forcefully eliminate a thin copper film by etching.

[0009] As explained above, the present invention enables both sides and edges of the wafer to be cleaned at the same time as well as preventing potential device problems caused by metals, such as copper, adhering to the edge section of the wafer. That is, device

performance problems caused by contamination from adhered metal on the edge section and back surface of the wafer, and problems of cross contamination caused by detached metal film from the copper formed on the edge section, are prevented. Thus, the invention provides beneficial effects of facilitating ideal cleaning of processed wafers that received various processing such as copper plating and a CMP process that follows the plating process.

[0010] The above and other objects, features, and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the present invention by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is an enlarged schematic view of a wafer W showing an edge portion and portions therearound;

[0012] FIG. 2 is an enlarged schematic view of a wafer W showing problems with conventional techniques;

[0013] FIG. 3 is a schematic diagram of the fundamental structure of a wafer cleaning apparatus of the present invention;

[0014] FIG. 4 is a diagram showing positioning of an etching nozzle;

[0015] FIG. 5 is a diagram showing another positioning of the etching nozzle;

[0016] FIG. 6 is an enlarged schematic view of a wafer being etched;

[0017] FIG. 7 is an enlarged schematic view of a wafer W having a poorly-defined step section of the outer periphery of a plating layer;

[0018] FIG. 8 is an enlarged schematic view of a wafer W whose outer periphery of the plating layer is also etched;

[0019] FIG. 9A is a diagram of an example of a process of integrating a plating section and the present wafer cleaning apparatus into one unit, and FIG. 9B is a diagram of an

example of a process of integrating a CMP section and the present wafer cleaning apparatus into one unit;

[0020] FIG. 10 is a diagram of an example of an apparatus produced by integrating a plating section and the present wafer cleaning apparatus into one unit; and

5 [0021] FIG. 11 is a diagram of an example of an apparatus produced by integrating a CMP section and the present wafer cleaning apparatus into one unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Preferred embodiments of the present invention will be explained in detail
10 in the following with reference to the drawings.

[0023] FIG. 3 shows a schematic diagram of the fundamental structure of a wafer cleaning apparatus of the present invention. As shown in this diagram, the wafer cleaning apparatus is comprised of a rotation mechanism 10 for holding and rotating a wafer W, two cleaning nozzles 31, 33, and an etching nozzle 35. Each of these components will be
15 explained below.

[0024] The rotation mechanism 10 includes a motor M so that wafer holding device 11 can be rotated through a belt B and pulleys P1, P2. Only two supporting portions of a wafer holding device are shown in this diagram, but in practice, 4~8 supporting portions of the wafer holding device are provided, and are arranged so as to hold an outer periphery of
20 the wafer W to maintain the wafer W horizontal. The wafer may be oriented so that the front surface thereof faces either upwardly or downwardly.

[0025] On the other hand, the cleaning nozzle 31 is disposed facing close to the front surface of the wafer W, which is a surface that has been fabricated such as being plated or subjected to a CMP process. Cleaning solution from the nozzle is directed to the center of
25 the wafer W. The cleaning nozzle 31 should be disposed below the wafer when the fabrication surface (front surface) of the wafer faces downwardly.

[0026] Cleaning solution “a” sprayed from the cleaning nozzle 31 should be a liquid substance that does not etch copper and is effective in removing metal and particulate contamination. For example, any one of pure water, diluted sulfuric acid, diluted hydrofluoric acid (DHF), ionized water, 2-stage processing with dilute hydrofluoric acid and
5 ozonized water, and 2-stage processing with hydrogen peroxide (H_2F_2) and diluted hydrofluoric acid may be used as necessary.

[0027] Next, the cleaning nozzle 33 is disposed facing the backside of the wafer; that is, the surface that has not been subjected to fabrication such as plating or a CMP process. The cleaning nozzle 33 should be disposed above the wafer when the back surface of the
10 wafer faces upwardly. The cleaning nozzle 33 is constructed in such a way that when the back surface of the wafer W faces downwardly, cleaning solution is sprayed in a shape of a cone.

[0028] Cleaning solution “b” sprayed from the cleaning nozzle 33, should be capable of removing Cu adhered on a silicon wafer when compared to the solution “a”, which is
15 sprayed on the front or fabricated surface of the wafer. The cleaning solution “b” may use, for example, any one of pure water, diluted sulfuric acid, diluted hydrofluoric acid, 2-stage processing with ozonized water and diluted hydrofluoric acid, and 2-stage processing with hydrogen peroxide and diluted hydrofluoric acid, as necessary.

[0029] As shown in FIG. 4, the etching nozzle 35 is installed so that the spray opening
20 of the nozzle is positioned at a specific distance so that k is less than 5 mm ($k < 5$ mm) from the edge section of the wafer W, and that the direction of the center line ℓ of the spray opening at the tip of the etching nozzle 35 is at right angles ($\theta_1 = 90^\circ$) relative to the surface of the wafer W.

[0030] The etching nozzle 35 may be installed, as shown in FIG. 5 also, so that the
25 spray opening of the nozzle is positioned at a specific distance so that k is less than 5 mm ($k < 5$ mm) from the edge section of the wafer W, and that the direction of the center line ℓ

of the spray opening at the tip of the etching nozzle 35 is inclined towards an outer edge at an angle other than right angles ($02 < 90^\circ$) relative to the surface of the wafer W.

[0031] Also, although only one etching nozzle 35 is provided in this embodiment, it is permissible to provide a plurality of etching nozzles. It is preferable that the fluid stream
5 ejected from the etching nozzle 35 be shaped to a fine point as much as possible so as to produce well defined etching boundaries.

[0032] Etching solution "c" to be sprayed from the etching nozzle 35 should be selected so that its purpose is to etch away the copper. For example, such a solution may be any one of a mixture of sulfuric acid and hydrogen peroxide, and a 2-stage processing based
10 on sodium persulfate, sulfuric acid, hydrochloric acid, nitric acid, ionized water or ozonized water and diluted hydrofluoric acid, as necessary.

[0033] Next, the operation of the wafer cleaning apparatus will be explained. That is, a wafer W that has been subjected to a fabrication process such as copper plating or a CMP process is held in the wafer holding device 11, as shown in FIG. 1, with the surface to
15 be fabricated (front surface) facing upwardly, and the motor M is operated to rotate the wafer W. Cleaning solutions "a" and "b" are sprayed from the cleaning nozzles 31, 33, and concurrently, an etching solution "c" is sprayed from the etching nozzle 35. Or, the etching solution "c" is sprayed from the etching nozzle 35 only initially for a given period of time, after which the cleaning solutions are sprayed from the nozzles 31, 33.

[0034] The cleaning solution "a" sprayed from the cleaning nozzle 31 rushes to the
20 center section of the front surface of the wafer W, and is then spread on the wafer surface throughout by the rotational action of the wafer W. Thereby, metal and particulate contaminants are washed away from the front surface of the wafer W, thus cleaning the front surface of the wafer W.

[0035] The cleaning solution "b" sprayed from the cleaning nozzle 33 rushes to the
25 back surface of the wafer W in a shape of a cone, and is spread out along the entire back surface by the rotational action of the wafer W, thereby removing metal and particulate

contaminants from the back surface of the wafer W and cleaning the back surface thereof. It is permissible to reverse the facing direction of the front/back surfaces of the wafer W.

[0036] In the meantime, the etching solution "c" sprayed from the etching nozzle 35 rushes to the peripheral portion of the surface of the wafer W at right angles, as shown by the arrow in FIG. 4. However, because the wafer W is rotating, it flows from the ejected position towards the outside by centrifugal force, and flows only to the outer periphery thereof. This action causes only the outer periphery, where the etching liquid "c" has adhered, to be selectively etched as shown in FIG. 6. In other words, because of the action of this selective etching, it is possible to remove an unnecessary thin Cu layer, formed by sputtering and the like on the edge section E of the wafer W shown in FIG. 2, and create the condition shown in FIG. 1. Therefore, there is no danger of the adhered Cu causing performance problems in a device during subsequent heating processes, or causing cross contamination by Cu during transport or post processing of the wafer W.

[0037] Also, when the step produced by a seal on the outer periphery of the plating layer 85 is not well defined, as illustrated in FIG. 7, a thin portion U is also formed on the plating layer 85 and may cause detachment. Therefore, it is necessary to etch seed layer 83 and the plating layer 85 together at thin portion U. When this thin portion U is selectively etched as described above, the condition shown in FIG. 8 can be obtained.

[0038] On the other hand, when the etching nozzle 35 is installed so that it is inclined away from the vertical toward the outer periphery as shown in FIG. 5, it is obvious that only the outer portion of the wafer W is selectively etched to produce the effects described above.

[0039] In the above embodiment, copper is used as an object metal for etching treatment, but this invention is not limited to copper, so that the invention can be applied to other metals such as gold, silver, or solder. Also, there are many types of rotational devices for the wafer, and any type of rotation device may be used so as long as rotational action can be produced.

[0040] Because the wafer cleaning apparatus is used for cleaning wafers that have been subjected to copper plating or CMP process, it is preferable that the wafer cleaning apparatus is constructed as an integrated unit by combining it with a plating section for performing copper plating or a CMP section for performing chemical mechanical polishing.

5 [0041] FIG. 9A shows an example of the process performed by a combined unit of a plating section and the wafer cleaning apparatus, and FIG. 9B shows an example of the process performed by a combined unit of a CMP section and the wafer cleaning apparatus.

[0042] FIG. 10 shows a schematic diagram of an example of an apparatus that combines a copper plating section and the wafer cleaning apparatus. As shown in this
10 diagram, a plating section 100 is comprised of a plurality of plating vessels 101, a robot 103, a loading stage 105 and a rough wash section 107. And, a cleaning section 110 is comprised of the present wafer cleaning apparatuses 111, 113, rinser dryers 115, 117, a robot 119, a loading wafer cassette 121, and an unloading wafer cassette 123. One wafer at a time is removed from the loading wafer cassette 121 by the robots 119, 103 and is transported to the
15 plating vessel 101 by way of the loading stage 105 for plating. Then, the plated wafer is washed in the rough washing section 107, and is etched in the present wafer cleaning apparatuses 111, 113 to etch the front and back surfaces and the outer periphery of the wafer. Then, the wafer is passed through the rinser dryers 115, 117 to clean and dry the wafer, and the dried wafer is returned to the unloading wafer cassette 123. In other words, a plating
20 operation and a cleaning operation are carried out in an interleaved manner on each wafer.

[0043] Also, FIG. 11 shows a schematic diagram of an example of the apparatus that combines CMP and the present wafer cleaning apparatus. As shown in this diagram, a CMP section 130 is comprised of a turntable 134 provided with a polishing surface, a rotating top ring 137 having a top ring head 135 for holding a wafer; a dresser 141 for dressing the
25 polishing surface; and a pusher 143 for exchanging a wafer with the top ring head 135. A cleaning section 150 is comprised of a primary washer 155; a secondary washer 157; a spin dryer 159; robots 151, 153; wafer inverters 161, 163 and wafer loading/unloading cassette

165. The wafers are taken one at a time from the wafer cassette 165, and are mounted on the top ring head 135 by way of the wafer pusher 143. Then, the wafer is subjected to chemical mechanical polishing using the polishing surface of the turntable 134, and is again handled by the wafer pusher 143 for rinsing in the primary washer 155 and the secondary washer 157. Then the wafer is spin dried in the spin dryer 159, and is returned to the wafer cassette 165. In other words, CMP operations and a cleaning operation are carried out in an interleaved manner on each wafer. The primary washer 155 may be represented by the present wafer cleaning apparatus.

[0044] Although certain preferred embodiments of the present invention have been shown and described in detail, it should be understood that various changes and modifications may be made therein without departing from the scope of the appended claims.